THROMBOTIC COMPLICATIONS IN BEATING HEART OPERATIONS

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Background: Off-pump coronary artery operations have recently gained popularity among the community of cardiac surgeons. Because the use of cardiopulmonary bypass is avoided, full anticoagulation is generally not sought to decrease perioperative blood loss and transfusion needs. Traditionally, patients undergoing coronary artery bypass operations with cardiopulmonary bypass are not considered at risk of having venous or arterial thromboembolic complications, and prophylaxis is generally not recommended.

Methods and results: We have reviewed our experience with off-pump coronary bypass operations, focusing on thromboembolic complications with clinical manifestations, and compared these findings with our experience with cardiopulmonary bypass operations. In our series of 500 off-pump cases, thromboembolic complications occurred in 1%, causing death in 1 patient, whereas in a contemporary cohort of 1476 patients operated on with cardiopulmonary bypass, thromboembolic complications resulted in stroke in 0.5% of the cases. This difference did not reach statistical significance.

Conclusions: Thromboembolic complications in off-pump coronary bypass operations are comparable with those in cardiopulmonary bypass operations. Although the prevalence of this complication remains low, the associated morbidity should lead to reconsideration of prophylactic measures. (J Thorac Cardiovasc Surg 2001;121:920-2)

Beating heart operations have recently gained popularity among the cardiovascular community. Because the use of a cardiopulmonary bypass (CPB) apparatus is avoided during these interventions, the level of anticoagulation required is generally lower than that found in the standard procedure with CPB. The CPB-related inflammatory response caused by the activation of plasma protein systems, such as contact system, intrinsic and extrinsic coagulations, complement, and fibrinolytic system, is accordingly reduced.[1] The usual postoperative CPB-generated coagulopathy does not occur. Although the temporary precariousness of the clotting system is generally seen as a negative aspect by the cardiac surgeons, it may help in preventing thrombotic complications normally seen after any surgical procedure. Postoperative hypercoagulability is a well-documented state after general and orthopedic operations and is responsible for significant postoperative morbidity.[2,3] The nonuse of CPB may offset some of the advantages of the conventional on-pump coronary revascularization and set the ground for postoperative thrombotic complications.

For the past 4 years, we have applied the systematic use of off-pump coronary artery operations to all cases of coronary revascularization, with the main contraindication being the preoperative hemodynamic instability. More than 95% of all our cases were performed off-pump during that time. Meanwhile, we have noted an increased incidence of postoperative thrombotic complications, and this is the object of the present report.

Methods and results

Off-pump operations. Between September 1996 and May 2000, 500 patients were operated on without CPB at the Montreal Heart Institute by a single surgeon. The average patient age was 64 ± 10 years, the majority of patients were male (80%), and the most common surgical indication was unstable angina (69%). On average, 3.1 grafts per patient were completed, and internal thoracic artery (ITA) conduits were used in more than 97% of the cohort. The incidence of perioperative myocardial infarction (1.7% Q wave) was similar to that found with conventional CPB operations[4] in our institution, and operative mortality remained low (1.3%). During the operation, all patients received an initial heparin dose of 1 mg/kg, with an additional bolus when necessary to maintain the activated coagulation time above 300 seconds.

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During the postoperative course, 5 (1.0%) patients had thrombotic complications, which caused 1 patient's death (Table I). Among this group, 3 patients had a pulmonary embolism during recovery after the operation.

The first patient, a 52-year-old man, had chronic renal insufficiency and had been on hemodialysis for many years. He had a pulmonary embolus, confirmed on the ventilation-perfusion nuclear scan, on postoperative day 5 after a triple coronary artery bypass graft. He was successfully treated with intravenous heparin and continued to receive warfarin sodium for 3 months.

The second patient was a 54-year-old diabetic man receiving optimal medical treatment who was operated on for unstable angina. Twenty-four hours before the operation, an intra-aortic balloon device was inserted because of persistent angina. The coronary angiogram revealed a significant left main stenosis and a significant triple-vessel disease. He was discharged on postoperative day 5 after an uneventful triple off-pump coronary artery bypass operation. A few days later, he was readmitted for a superficial wound infection and kept in the hospital for intravenous antibiotics. Two days later, without warning signs, the patient had a cardiac arrest. All attempts to resuscitate him were unsuccessful, even though they were immediately initiated. An autopsy revealed a massive embolism at the pulmonary artery bifurcation with an extensive right iliofemoral deep venous thrombosis ipsilateral to the site of the intra-aortic balloon device. All coronary artery grafts were found patent at the autopsy.

Another 48-year-old man underwent an elective triple coronary artery bypass with arterial graft only (sequential diagonal–left anterior descending arteries with the left ITA and right coronary artery grafting with the right ITA). The operation was uneventful, but on the third postoperative day, he reported a sudden pleuretic pain to the right side of the chest. Nuclear scan revealed multiple pulmonary emboli, mainly spread to the right lung. No leg deep vein thrombi were detected by means of Doppler scanning. He was given anticoagulant medications for 3 months.

Two other patients (a 61-year-old woman and a 62-year-old man), after successful coronary revascularization without complications for unstable angina, returned with an extensive iliofemoral deep vein thrombosis (DVT). One of them had an intra-aortic balloon device installed 24 hours before the operation because of refractory unstable angina. They were both anticoagulated with warfarin for 3 months without any other complications.

No patient had any history of DVT or pulmonary embolism. No standard prophylactic regimen for preventing DVT was applied, although 4 of these patients were receiving intravenous heparin for unstable angina before the operation. Heparin-induced thrombocytopenia was not suspected in any of them. No patient received antifibrinolytic drugs before or during the operation.

CPB operations. To compare the prevalence of postoperative thrombotic complications in off-pump operations with those in conventional operations, we have revised the incidence of this complication in patients operated on with the use of CPB at the Montreal Heart Institute. Between April 1998 and March 2000, 1476 patients underwent isolated coronary artery revascularization with CPB in our institution. Among them, 8 (0.50%) patients sustained venous thromboembolic complications within the first 3 postoperative months (Table I). Antifibrinolytic drugs were not routinely used during this period. Among those who presented with DVT, the majority had the process limited to the infrapopliteal area. Moreover, 4 patients had significant predisposing factors. Heparin-induced thrombocytopenia was suspected in 1 patient, a second patient had a perioperative cerebrovascular accident that left him with right hemiplegia, a third patient was readmitted with a mediastinitis that required re-exploration and prolonged hospitalization, and the fourth patient had an adrenal tumor diagnosed on an abdominal CT scan. The patient died of a massive pulmonary embolism, and autopsy was refused by the family. A paraneoplastic syndrome was suspected.

Table I. *Prevalence of venous thromboembolic complications in off-pump coronary artery bypass operations and CPB operations*

	Venous thrombosis			
	Infrapopliteal	*Iliofemoral*	*PE*	*Total (%)*
OPCAB (n = 500)	–	2	3	5 (1.0)
CPB (n = 1476)	4	1	3	8 (0.5)*

OPCAB, Off-pump coronary artery bypass.
*P = .42.

Discussion

Tissue damage during major surgical procedures releases a significant amount of tissue factor into the venous circulation. As this procoagulant compound passes through the lung capillaries, a significant amount of thrombin is generated, which contributes to postoperative hypercoagulability.[2] Animal studies have shown that damage to bone marrow could be a major factor in postoperative hypercoagulability.[5] This is particularly significant in cardiac operations, in which a standard sternotomy approach is routinely used. The median sternotomy frequently induces significant bleeding through the bone section and encourages seeding of procoagulant factors across the surgical field. Locally, it induces the release of thrombin-antithrombin complexes and increases tissue plasmin activator. Furthermore, high thrombin generation has been associated with coronary artery disease, along with the presence of high tissue factor levels.[6] All these factors directly contribute to create a postoperative phase of hypercoagulability.

Some of our patients in the off-pump cohort had predisposing factors, such as chronic renal failure and the insertion of an intra-aortic balloon device before the

operation. However, none of these patients were obese, they were all younger than 70 years of age, none had a history of DVT, and 1 was even admitted the day of the operation. Conversely, predisposing factors for DVT appeared more frequently in the conventional group, although patients in both groups were given coated aspirin early after the operation (<6 hours). Because most of our patients at the Montreal Heart Institute do not meet the classic criteria for systematic evaluation of thrombophilia, we do not screen our patients for prothrombotic syndrome. Furthermore, the incidence of these disorders is low in the general white population, representing 0.14% to 0.9% for protein C deficiency, 0.7% for protein S deficiency, 0.17% for antithrombin III deficiency, 5% for factor V Leinden mutation in heterozygous form, 2.3% for the prothrombin gene mutation (G20210A), and 9% to 10% for hyperhomocysteinemia.[7] Consequently, beside hyperhomocysteinemia, the association between a congenital hypercoagulable state and the thrombotic episodes of our patients is unlikely and still does not explain, by itself, the apparent excess of thrombosis in the off-pump cohort. It is also noteworthy that this potential hypercoagulable state did not translate into an increased prevalence of perioperative myocardial infarction in the off-pump cohort.

Although thromboembolic complications appear more frequently in our off-pump coronary artery operation cohort, this did not reach statistical significance when compared with the cohort undergoing conventional operations. The 1% incidence of venous thromboembolic complication that we observed represents only those that were clinically obvious cases without any specific postoperative screening and consequently does not rule out any subclinical active cases. Interestingly, in a recent collective review on prevention in venous thromboembolism,[3] no specific recommendations were made for cardiac patients undergoing coronary artery operations, suggesting that DVT prevention has never been seen as a necessity by cardiac surgeons. Classically, general surgical and orthopedic patients are considered at high risk for DVT. The most recommended prophylaxis consists of low-dose unfractionated heparin (ie, 5000 units given every 8 to 12 hours and commencing 1 to 2 hours before the operation) or, alternatively, low-molecular-weight heparin.[3] These regimens have shown a reduction of relative risk of DVT of 68% to 72%.

Currently, although the incidence of postoperative thromboembolic complications in off-pump coronary artery operations remains low, the associated morbidity deserves consideration. Consequently, we have recently opted for a standard prophylactic anticoagulation regimen (subcutaneous heparin 5000 units 3 times a day starting 1 to 2 hours before the operation) that we generally maintain until the patient is discharged. More studies are needed on these topics to substantiate our preliminary observations and define the optimal prophylactic therapy in coronary artery bypass grafting operations.

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REFERENCES

1. Edmunds LH. Inflammatory response to cardiopulmonary bypass. Ann Thorac Surg 1998;66:S12-6.
2. Dahl OE. Mechanisms of hypercoagulability. Thromb Haemost 1999;82:902-6.
3. Clagett GP, Anderson FA, Geerts W, Heit JA, Knudson M, Lieberman JR, et al. Prevention of venous thromboembolism. Chest 1998;114:531S-60S.
4. Cartier R, Brann S, Dagenais F, Martineau R, Couturier A. Systematic off-pump coronary artery revascularization in multivessel disease: experience of three hundred cases. J Thorac Cardiovasc Surg 2000;119:221-9.
5. Dahl OE. The role of the pulmonary circulation in the regulation of coagulation and fibrinolysis in relation to major surgery. Cardiothorac Vasc Anesth 1997;11:322-8.
6. Falciani M, Gori AM, Fedi S, Chiarugi L, Simonetti I, Dabizzi RP, et al. Elevated tissue factor and tissue factor pathway inhibitor circulating levels in ischaemic heart disease. Thromb Haemost 1998;79:495-9.
7. Van Cott EM, Laposera M. Laboratory evaluation of hypercoagulable states. In: Neufeld EJ, editor. Hematology/oncology clinics of North America: coagulation disorders and treatment strategies. Philadelphia: WB Saunders; 1998. p. 1141-66.